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INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION
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BIOLOGICAL EVALUATION OF SPRUCE BUDWORM INFESTATION IN THE NORTHERN ROCKY MOUNTAIN REGION 1959

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SUMMARY

The current spruce budworm outbreak in Forest Service Region One began in the early 1940's. At present almost 6 million gross acres are infested, and the epidemic shows no evidence of decline. Most of the available dry-site Douglas-fir type in Montana is infested, and much acreage sprayed in 1953 through 1958 to control the budworm is reinfested to a marked degree.

Until 1959, budworm conditions were determined primarily by measuring the amount of defoliation sustained by Douglas-fir stands. This year surveys were directed toward evaluating budworm conditions on the basis of biological measurements, with emphasis placed on determining population trends. Twenty-five permanent, and 64 semipermanent sample plots were located at various points in Montana and several kinds of surveys were made on these plots. This report describes the methods employed in conducting these surveys, and the results that were obtained. Each type of survey shows that the budworm outbreak continues in much the same status as in 1958.

INTRODUCTION

Spruce budworm Choristoneura fumiferana (Clem.) infestations have been common to the northern Rocky Mountain region for several decades--perhaps longer. Since the first reported outbreak in 1921 few years have passed without epidemic conditions somewhere in the region. Since about 1940 infestations have been more persistent and have reached epidemic status in large areas in the region. Annual increases in acreage of budworm infestation were recorded from 1949 to 1958. During this period the infestation covered nearly 6 million gross acres[1/] of forest in the region (figure 1). Most of the damage occurred in pure, dry-site Douglas-fir timber type in Montana. Several hundred thousand acres of infestation in Idaho in timber types comprised of grand fir, subalpine fir, and Douglas-fir suffered to a lesser extent. The increase in infested acreage was comparatively small in 1957 and 1958. Comprehensive survey data to record changes in infested acreage is lacking for 1959; however, there is no evidence of any major change. In fact, it might be feasible to declare endemic nearly 200,000 acres of infestation sprayed in Idaho in 1955 and 1956. Table 1 presents available data on gross infested acreage and budworm control during the past 13 years.

1/ Gross acres include some areas of non-host type, openings, and barren ridges. (Net infested acreage is estimated at 66 percent of gross acreage.

SPRUCE BUDWORM SURVEYS IN THE NORTHERN ROCKY MOUNTAIN REGION, 1959

CONTROLLED AREAS

1952 1953 1955 1956 1957 1958 1959

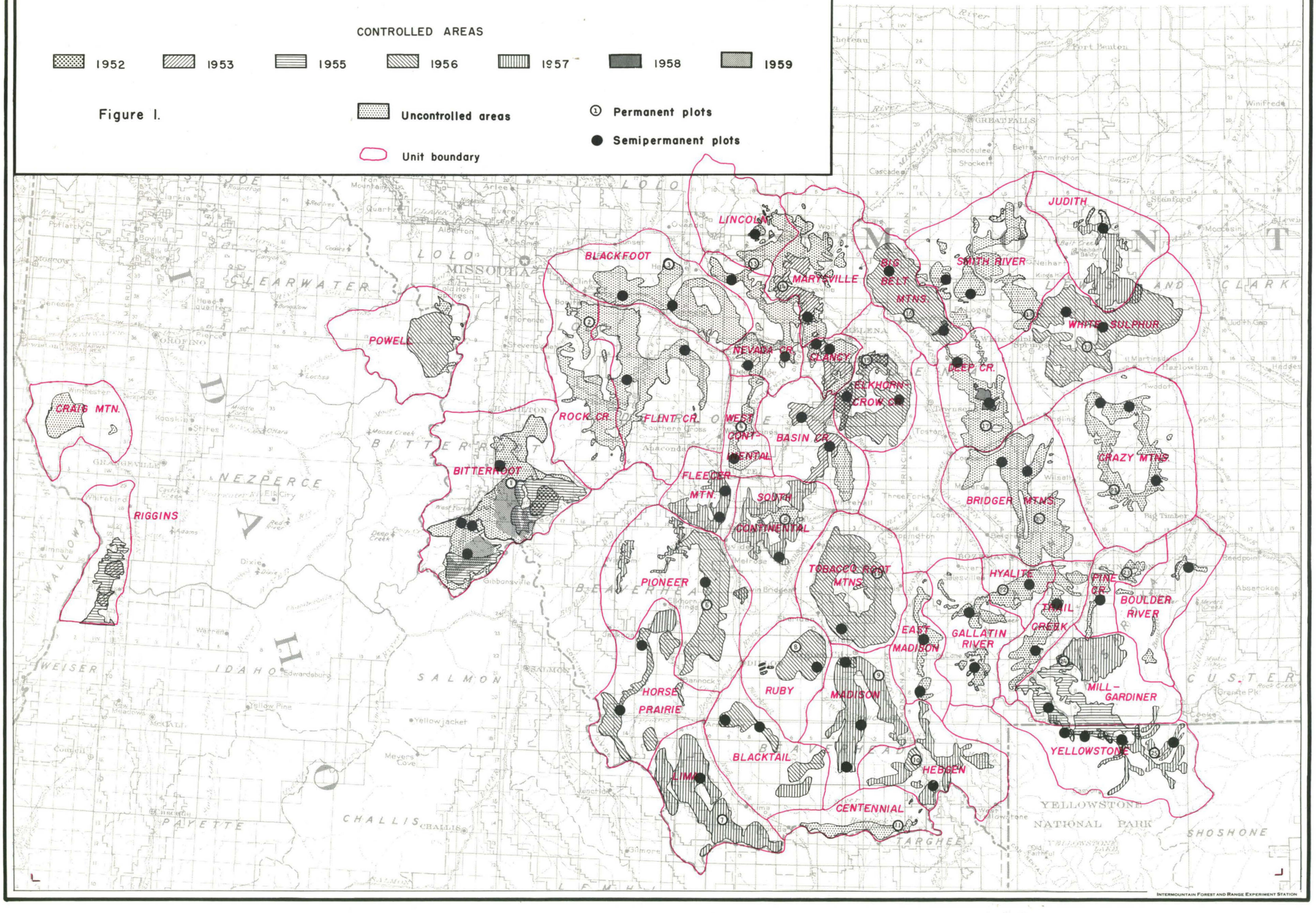
Figure 1.

Uncontrolled areas

Unit boundary

① Permanent plots

● Semipermanent plots



INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION

Table 1.--Cumulative annual acreage of uncontrolled and controlled spruce budworm infestations in the northern Rocky Mountain region, 1947-1959

Year	Cumulative total infested at previous year end and beginning of current year	Newly infested during year	Cumulative total infested at year's end	Controlled by aerial spraying during year	Respray of previously sprayed infestation	Controlled by natural factors during year	Uncontrolled at year's end
1947-1949		542,100[1/]					
1950	542,100	330,060	872,160				872,160
1951	872,160	502,000	1,374,160				1,374,160
1952	1,374,160	961,000	2,335,160	12,000		214,000	2,109,160
1953	2,335,160	330,000	2,665,160	135,215			2,303,945
1954	2,665,160	84,000	2,749,160				2,387,945
1955	2,749,160	1,341,000	4,090,160	341,873	28,070	58,000	3,329,072
1956	4,090,160	1,318,000	5,408,160	848,970	36,352	2,000	3,796,102
1957	5,408,160	249,000	5,657,160	737,538	47,440	2,000	3,305,564
1958	5,657,160	230,840	5,888,000	14,700	3,500		3,521,704
1959				78,753	48,128		3,442,951
Totals				2,169,049	163,490	276,000	

1/ Cumulative during 1947-1949

Spruce budworm surveys made by Forest Insect Laboratory personnel have varied in intensity and design since they were initiated in 1948. During the infestation build-up period, surveys were designed to map and record annual damage. Later, when extensive aerial spraying programs were undertaken, emphasis was placed on biological evaluation of the outbreak. In 1959 national forest personnel made operational surveys in several areas where control measures were planned; the Laboratory confined its efforts to a region-wide biological evaluation of the outbreak.

Because spruce budworm infestation is apparently a chronic condition in many Douglas-fir stands in Montana, the need for biological information on budworm epidemiology is great. In 1959 a decision was made to attack the problem by initiating a survey program to serve both immediate and long range needs. The survey plan has an additional objective of testing the effectiveness of several types of survey methods.

METHODS

The present survey program was set up by establishing 25 permanent sample plots at various points in Montana. An additional 64 semipermanent plots were also established from which only foliar damage data were taken (figure 1). Four different survey treatments were made on the 25 permanent plots: (1) A spring survey of overwintering larvae (2) emerged moth survey in late July (3) September, egg mass and (4) damage survey (Table 2). A progress report covering research on survey improvement techniques will be issued at a later date.

Two things will be accomplished with these plots: Annual surveys of the same plots will provide comparable basic data from which to measure infestation trends; repetitive surveys of the same plots during different phases of budworm development will compare the effectiveness of various types of surveys.

Each plot consists of five or more intermediate Douglas-fir trees located in a fairly even-canopied stand. Except for the overwintering larval survey, all subsequent surveys will be made on the same trees in each plot as long as the trees remain suitable. Periodic substitution will be made when limbs removed in sampling eventually denude the midcrown portions of the trees. In each plot trees are marked with painted numerals for easy identification.

The following procedures were used for the different surveys:

Overwintering larvae.--During the period April 1 to mid-May, six, 6- to 8-inch diameter Douglas-fir trees were felled at each plot location. A single bole section about 17 inches long was cut from each tree near midcrown, shortly below the junction of smooth and rough bark. These billets were taken to Missoula, Montana where the larvae, hibernating in crevices and under bark flakes, were forced into early emergence by artificial treatment[2/]. The number of emerging larvae was computed on the basis of larvae per square foot of bark surface.

On all succeeding surveys five trees were used for sampling.

Emerged moth.--During late July and early August a survey was made to determine the population of emerged budworm moths. This was accomplished by counting pupal cases from which moths had emerged, in lieu of moths, and by collecting pupae where still present in the foliage and holding them for emergence. Four, 15-inch twigs were cut from the cardinal sides at lower midcrown from each of five trees. Pupal cases were counted and pupae were collected on each twig. The number of buds per each twig were also recorded. In the final analysis moths could be tabulated on the basis of twigs or buds.

Defoliation.--In September the foliar damage caused by current larval feeding was estimated on each of the five plot trees. A method used successfully by entomologists of the Pacific Northwest Forest and Range Experiment Station was used for the first time in Region 1. Each tree was observed through 9 x 35 power binoculars at a range close enough to enable the viewer to examine individual buds and needles in upper, middle and lower thirds of the crown. Percentages of defoliation were estimated for each crown third. The accuracy of ocular estimates was checked periodically by measuring defoliation on typical branches. Estimates for each third were then weighted by the multipliers 1, 3, 5 for upper, middle and lower portions, respectively, to compensate for the greater complement of foliage in the middle and lower crown. The results were then divided by 9 to obtain a weighted estimate of defoliation for each tree.

In addition to the 25 permanent plots, 64 plots were established from which only defoliation data were taken in 1959. These extra plots gave a more intensive sample for the defoliation phase of the survey and will serve as a reservoir of plots when needed in the future.

2/ Terrell, Tom T. 1959. Sampling populations of overwintering spruce budworm in the northern Rocky Mountain region. Research Note 61, Intermountain Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture, Ogden, Utah, 8 pp., illus. March, 1959.

Egg mass.--In conjunction with the defoliation survey, material was collected for budworm egg mass counts. The equivalent of one whole branch from midcrown was collected from each of the five trees. Foliage surface area of each half-branch was measured in square feet. Foliage from each plot was transported to a temporary laboratory at Townsend, Montana. Here, a crew of 4 women inspected the foliage and collected all needles having budworm egg masses or foreign substance resembling egg masses. This material was later sorted by entomologists who picked out the needles having egg masses and separated them into those with new (1959) and old (1958) egg masses. These data were recorded on the basis of egg masses per 1000 square inches of foliage.

RESULTS

An analysis of all the data taken, or any one category of it, shows that the budworm outbreak continues in much the same status as in 1958. Results obtained on the several surveys of the permanent sample plots are given in table 2.

Old budworm egg masses averaged 8 per 1000 square inches of foliage. This level of egg mass abundance is considered medium in a range of low, medium, high, and very high. It is obvious (2nd column, table 2) that a considerable population of larvae was produced from these eggs--sufficient to consume 40 percent of the foliage on these plots (column 3).

The emerged moths shown in column 4 represent the lowest population point in budworm life history. An average of one moth per 15-inch twig resulted from 19 overwintering larvae per square foot of bark surface. These moths laid the egg masses represented in the last column in table 2. There is considerable variation in the number of both old and new egg masses in the different samples. The small difference between the averages of old and new egg masses is not statistically significant. Because the number of 1959 egg masses are much the same as in 1958 the current eggs can be expected to produce an overwintering larval population comparable to that in 1958-1959.

Table 2.--Spruce budworm survey data from 25 permanent plots with related statistics for five different phases of activity in the order of occurrence

Plot	1 Egg masses per 1000 sq. in. 1958	2 Overwintering larvae per sq. ft. 1959	3 Percentage of defoliation 1959	4 Moths per 15 in. twig 1959	5 Egg masses per 1000 sq. in. 1959
1 Bitterroot	0.58	1.5	8.6	0.00	0.00
2 Rock Creek	9.80	---	44.3	---	10.80
3 Blackfoot	11.44	14.5	42.3	3.20	16.56
4 West Continental	13.40	36.9	43.7	0.40	11.66
5 South Continental	16.12	13.0	62.2	1.40	7.78
6 Pioneer	0.94	1.6	35.2	0.10	0.32
7 Lima	0.50	0.1	13.5	0.05	0.24
8 Ruby	0.98	10.2	11.3	0.25	3.26
9 Madison	17.66	5.9	34.7	0.60	18.46
10 Hebgen	0.00	0.5	0.3	0.00	0.18
11 Centennial	4.74	28.1	54.5	0.90	12.64
12 Tobacco Root	1.34	0.0	1.8	0.00	0.00
13 Lincoln	12.66	101.4	72.7	2.65	21.98
14 Marysville	4.86	12.3	53.3	2.70	35.18
15 Elkhorn	6.30	8.6	50.1	1.15	10.62
16 Big Belt Mtns.	2.04	0.1	4.0	0.50	1.10
17 Deep Creek	20.48	2.2	36.8	1.85	15.66
18 Smith River	14.64	---	84.4	2.70	21.32
19 White Sulphur	6.88	3.7	90.0	3.50	36.58
20 Bridger	12.92	3.0	67.5	0.65	10.36
21 Crazy Mtns.	10.32	35.3	12.9	0.65	3.92
22 Hyalite	3.84	---	30.2	---	3.56
23 Pine Creek	19.16	84.5	92.8	0.55	7.28
24 Mill Creek	7.40	1.8	11.8	0.15	2.32
25 Slough Cr.(YNP)	5.14	55.5	55.0	1.15	4.08
Total	204.14	420.7	1013.9	25.10	255.86
Average	8.16	19.1	40.6 1/	1.09	10.24

1/ Additional plots in table 3 reduced this figure to 36 percent.

There is a very good correlation between the 1958 egg masses and the 1959 defoliation. If this relationship holds true, the defoliation in 1960 may be similar to that in 1959. (Defoliation is influenced by two factors: larval feeding and foliage growth. Variation in the amount of defoliation does occur from a fluctuation in either one or both of these factors.)

Although defoliation is not a good criteria for predicting the future course of an outbreak, it is the best measure of the effects of one. Defoliation damage data are, currently, the only means available to compare current and past budworm activity.

Former surveys and current data show the percentage of defoliation as:

1957	49 percent
1958	48 percent
1959	36 percent

The defoliation for 1959 in the foregoing tabulation is 4½ percent less than that given in column 3, table 2. The reason for this difference is: table 2 includes only the 25 permanent plots while the above tabulation contains the average of 89 plots.

Defoliation damage data from all but a few of the 40 budworm infestation units show a wide range of defoliation in the region (table 3). There is even considerable variation within many units. Part of this variation is probably due to past control activities and part is due to difference in infestation intensities.

Biological influences affecting the budworm outbreak are currently ineffectual in reducing the infestation. Parasitism of the overwintering larvae ranged from 20 to 38 percent, a level that has changed little during the past several years. The degree of parasitism of mature larvae and pupae was not significant in 1959. Egg parasitism in 1959 egg masses was about 1 percent--a low level.

From all these associated data and observations, indications point to a continuation of the spruce budworm outbreak at its present high level in 1960.

Table 3.--Percentage of defoliation in 1959 by units and plots

Unit	Percent defoliation	Unit	Percent defoliation
Basin Creek	84	Horse Prairie	20
Basin Creek	82	Horse Prairie	14
Bitterroot	76	Hyalite	39
Bitterroot	31	Hyalite	30
Bitterroot	28	Judith	15
Bitterroot	9	Lincoln	79
Bitterroot	5	Lincoln	73
Blackfoot	42	Lima	13
Blackfoot	31	Lima	9
Blackfoot	24	Madison	35
Big Belts	8	Madison	4
Big Belts	6	Madison	3
Big Belts	4	Madison	1
Blacktail	30	East Madison	89
Blacktail	20	East Madison	19
Boulder	83	Marysville	88
Bridger	72	Marysville	53
Bridger	67	Mill-Gardiner	12
Bridger	7	Mill-Gardiner	12
Centennial	54	Nevada Creek	71
Clancy	43	Nevada Creek	63
Clancy	38	Nevada Creek	21
So. Continental	62	Pioneer	35
So. Continental	1	Pioneer	5
W. Continental	46	Pine Creek	93
W. Continental	44	Pine Creek	45
Crazy Mtns.	52	Rock Creek	44
Crazy Mtns.	34	Ruby Mtn.	11
Crazy Mtns.	13	Ruby Mtn.	5
Crazy Mtns.	2	Smith River	86
Deep Creek	68	Smith River	70
Deep Creek	37	Smith River	15
Deep Creek	6	Trail Creek	88
Elk Horn-Crow Cr.	50	Trail Creek	53
Elk Horn-Crow Cr.	22	Tobacco Root Mtns.	13
Elk Horn-Crow Cr.	8	Tobacco Root Mtns.	2
Flint Creek	65	White Sulphur	90
Flint Creek	17	White Sulphur	49
Flint Creek	16	White Sulphur	19
Fleecer Mtn.	59	Yellowstone Park	64
Fleecer Mtn.	44	Yellowstone Park	55
Gallatin River	82	Yellowstone Park	1
Gallatin River	42	Yellowstone Park	0
Hebgen	3	Yellowstone Park	0
Hebgen	0		
		Average	36